



SUMMARY
RESOURCE AND POTENTIAL
RECLAMATION EVALUATION

BISTI WEST STUDY SITE
BISTI COAL FIELD

EMRIA
REPORT 5 -1976

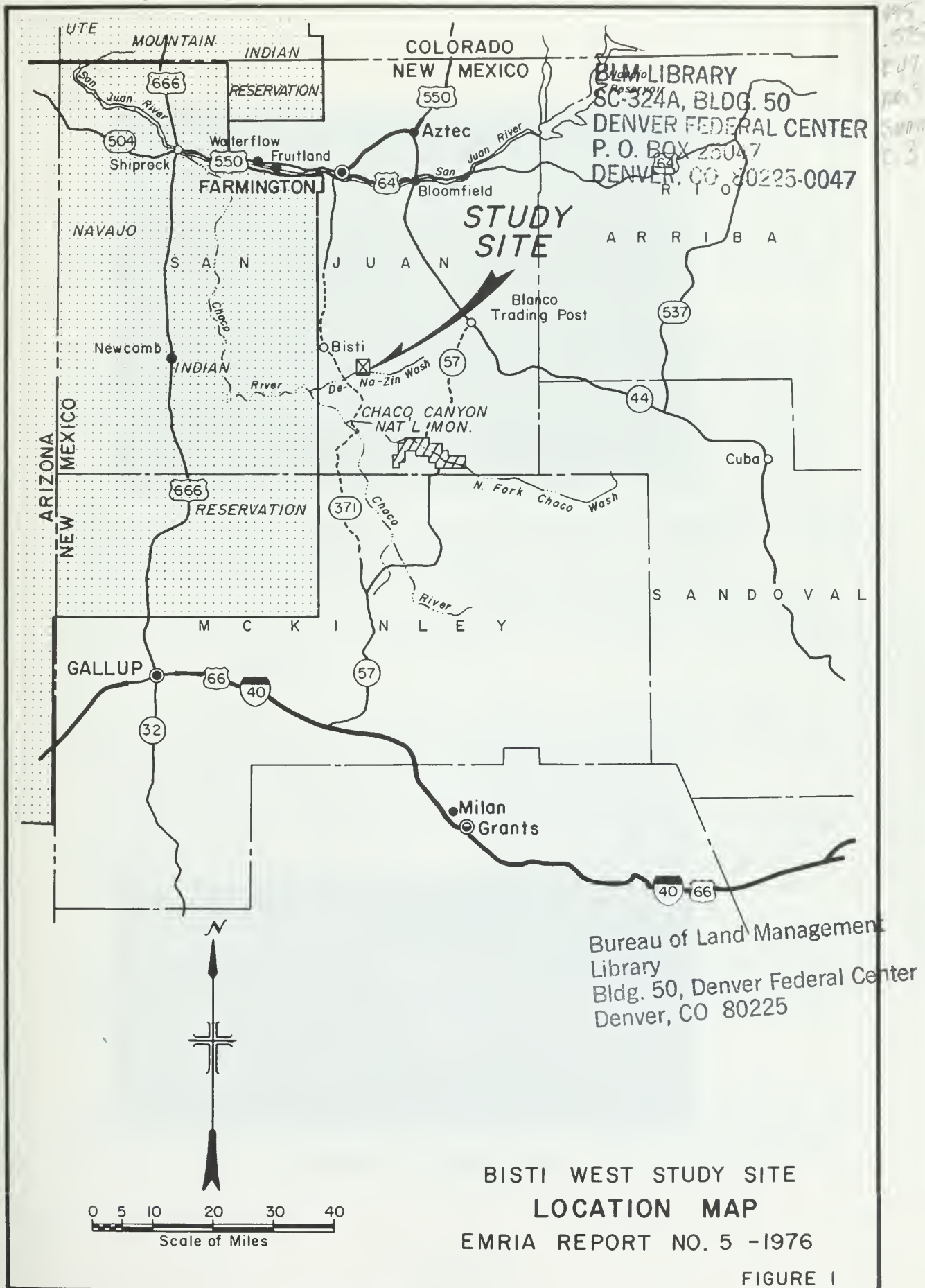
U.S. Department of the Interior

Bureau of Land Management - Bureau of Reclamation - Geological Survey

EMRIA - Energy Mineral Rehabilitation Inventory and Analysis

EMRIA is a coordinated approach to collection, analysis, and interpretation of overburden, water, and energy-resource data. The main objective of the effort is to assure adequate baseline data for choosing reclamation goals and establishing lease stipulations.

These reports are prepared through the efforts of the Department of the Interior--principally by the Bureau of Land Management, Bureau of Reclamation, and Geological Survey. Assistance is also provided by other Federal and State Agencies.





Looking south from Alamo Mesa. Edge of mesa in foreground; badlands in middle ground; valley lands and De-Na-Zin Wash (light streak) in background. Picture illustrates typical features of study site.



Coal outcrop at study site.

OVERVIEW OF RECLAMATION

Potential for Reclamation

Lands of the Bisti West study site will provide only a limited quantity of material suitable as a planting media (when placed on shaped spoils). There is enough suitable material, however, to allow postmining revegetation at about existing levels provided the recommendations for reclamation summarized below are implemented.

Most suitable materials are found on the surface both at higher elevations and as eolian deposits in the valley lands. These materials are generally coarse- to moderately coarse-textured, have adequate permeability, and are usually nonsaline and nonsodic. Only about 30 percent of study site lands were identified as having suitable planting media. Figure 2 shows the results of the land classification survey made to determine the extent and location of lands with material suitable for use as planting media. Lands in classes 1 (good), 2 (fair), and 3 (poor) have strippable quantities of suitable material; lands in class 6 have materials which are unsuitable in their present condition but which may be suitable under special management.

Because of salinity and restricted permeability resulting from sodium and swelling-type clays, bedrock overburden is generally not suitable as planting media. There is a possibility of limited use of such overburden under special management.

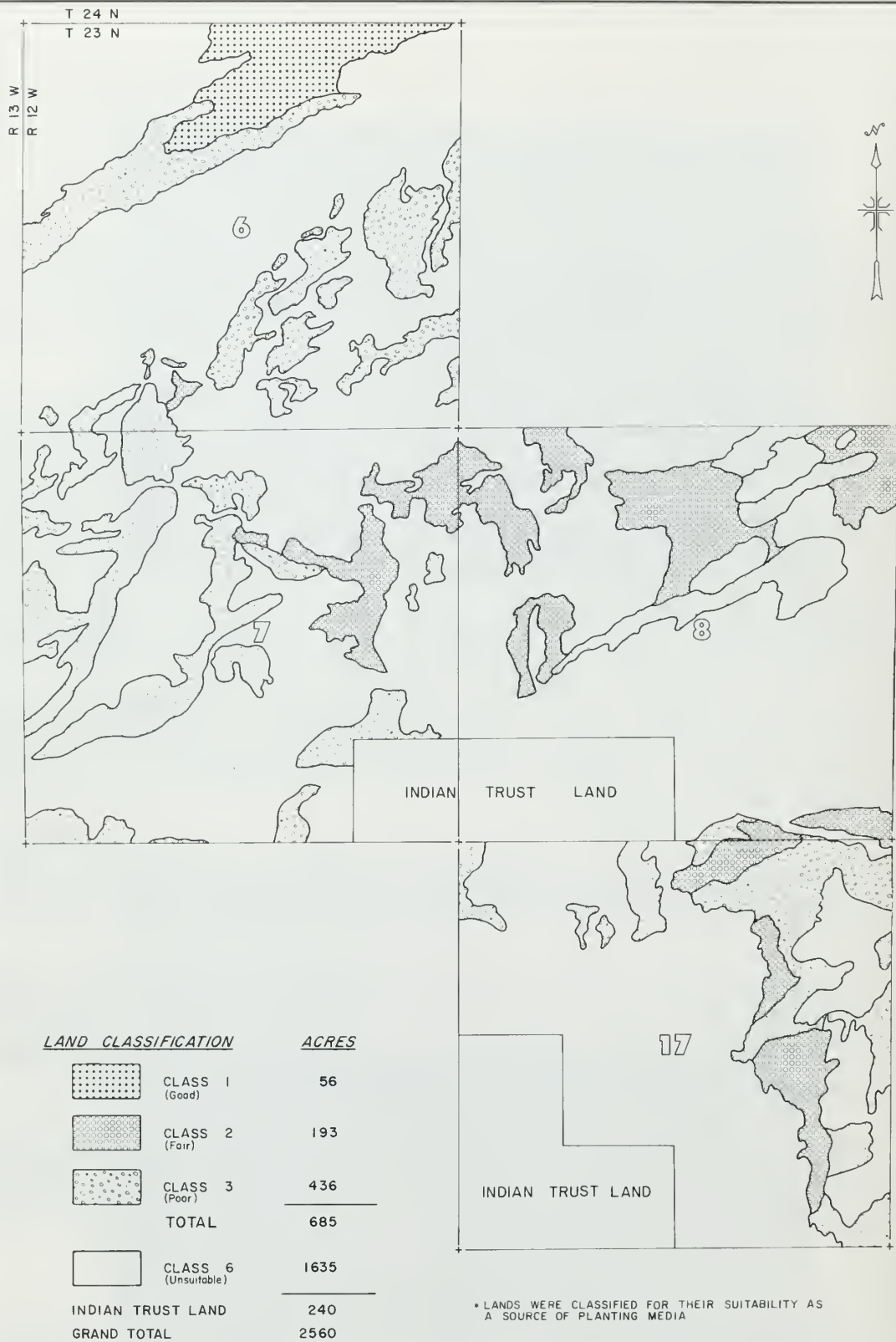
The harsh climate at the study site, typical of arid areas in this region and characterized by low precipitation occurring in erratic patterns (spotty local thunderstorms and some snow), will make revegetation difficult.

These precipitation patterns, sparse vegetation, surface and subsurface materials with low permeability, and relatively steep gradients could produce high runoff. Data for the site are presently inadequate, however, to predict long-term runoff patterns. The monitoring program started at the study site should provide data in the future.

The possibility is good that irrigation water for revegetation can be obtained from the nearby Navajo Indian Irrigation Project. Obtaining a firm supply of irrigation water from alternative sources will probably be more difficult and costly.

Recommendations for Reclamation

Four alternatives--no mining, natural recovery, total revegetation, and partial revegetation--have been considered for postmining reclamation. Of these, partial revegetation is recommended. Under this alternative,



BISTI WEST STUDY SITE
COMPOSITE LAND CLASSIFICATION
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the entire site would be carefully graded, but only part of it would be revegetated to approximate the existing level of vegetative cover. The rest of the site would be restored so as to minimize erosion and then be allowed to revegetate naturally. The recommendations that follow apply to the partial revegetation alternative.

Before mining, a detailed study should be made to more precisely establish the nature and location of soils and bedrock overburden suitable for planting media. During mining, these materials should be carefully stockpiled and protected. All toxic materials should be buried below root zone. Soils and bedrock overburden classed as unsuitable are not recommended for use as planting media in their present conditions but should be further investigated for such use under special management.

After mining, the site should be carefully graded to blend with surrounding land forms, utilize rainfall, promote revegetation, provide drainage, and minimize erosion. In order to reduce erosion and sediment yield, wide, flat drainageways should be constructed in the reshaped topography to accommodate flows that originate on the reclaimed area and upstream.

Selected graded areas should be covered first with about a foot of fine-textured soil and then with about 16 inches of suitable coarse-textured soil. This layering will promote permeability and water retention. Soil types could also be mixed as appropriate to improve the poorer materials. The use of fertilizer before, during, and after seeding may be desirable. Seeding should be done carefully, preferably with the drill method. Species (native and of local origin), seed mixes, seeding rates, and seeding times determined by the reclamation manager as appropriate to local conditions should be used.

Irrigation is recommended for about 2 years following seeding in order to establish vegetation, but irrigation should be compared with other alternatives for establishing the vegetation. One alternative is successive yearly seedings and continuous erosion control until establishment is achieved. Before irrigation is chosen, a firm water supply should be established.

After seeding, soil surfaces should be protected by mulches and wind barriers. Temporary use of herbicides on annual weeds may be necessary. Vegetation must be protected from grazing of domestic livestock until established.

De-Na-Zin Wash and Coal Creek (main study site drainages) may have to be excluded from the mining operation to preclude possible difficulty in controlling high discharges and to preclude adverse effects on area and downstream surface and shallow ground water supplies. Other recommendations for preventing adverse effects on the hydrology of the area are: divert upstream runoff around the mine and reclamation areas (during

construction); evaporate seepage and waste water in off-channel ponds; and continue and expand the hydrologic monitoring program established for this study before, during, and after mining.

CLIMATE

The Bisti West study site has an average annual temperature of 52°F, ranging from averages of 29°F in January to 76°F in July. The frost-free season is about 170 days. Average annual precipitation, usually in the form of localized intense thunderstorms, is about 8 inches, with July, August, September, and October each averaging about 1 inch. The remaining months each average about 0.5 inch. Up to 7 inches of the 8-inch total precipitation is effective. Average humidity is about 50 percent, and average annual pan evaporation is 50 inches.

These averages fail to portray adequately the harsh climatic picture which emerges when the extremes of weather in this area are considered. The most severe restraint on vegetative growth is precipitation. The 8-inch average includes years with 4 inches and years with 20 inches. Typically, there may be a 3-month period with no precipitation, perhaps followed by a brief heavy thunderstorm, followed by another long, dry period. This erratic precipitation pattern and other climatic factors will largely contribute to the difficulty in revegetating the study site.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The study site is in the Navajo Section of the Colorado Physiographic Province. Landforms in the Navajo Section are in an early stage of dissection, characterized by young plateaus, mesas, hogbacks, retreating escarpments, and debris-choked dry-wash canyons.

In the study site, sharply contrasting landforms include boldly scarped mesas, starkly barren badlands, hummocky areas, inactive and active sand dunes, and sand-choked drainages. Elevations range from 5870 to 5960 (feet above sea level) over most of the study site. Almost all drainage in the study site is to De-Na-Zin Wash, which flows west across the center of the site, and thence to the Chaco River, a left tributary to the San Juan River.

GEOLOGY

The dominant structural element of the study site region is the San Juan Basin, an asymmetrical structural and topographical depression roughly 125 miles long north-south and 100 miles wide east-west. Differential uplift in the region resulted in the basin's great, shallow bowl-like form. The perimeter of the basin, except on the south, is marked by sharp monoclinial flexures, or faulting, adjacent to the surrounding

mountains. The basin contains sediments ranging in age from Cambrian to Quaternary and having a maximum total thickness exceeding 14,000 feet in the deepest, or northern, part. Successively younger strata outcrop from the margins of the basin toward its interior--the Central Basin. The study site is situated in the southwestern quadrant of the Central Basin, where rock formations dip gently northwest.

The rock formations outcropping in the study site are of Late Cretaceous age and, in descending order, are: the lower part of the Kirtland Shale, consisting predominantly of shale; the Fruitland Formation, of shale, sandstone, coal, and siltstone; and the Pictured Cliffs Sandstone, of predominantly sandstone. All of the formations are weakly to only moderately lithified. "Hard rock" does not occur except for scattered ferruginous-cemented concretions in sandstone and siltstone beds in the Kirtland Shale and ferruginous-cemented thin sandstone beds in the Fruitland Formation.

In the study site, coal beds are confined to the Fruitland Formation and are thicker and more persistent in its lower part. Coal beds range from .6 to 20 feet in thickness, averaging about 5 feet in thickness. Depth of overburden above the upper coal beds ranges from 0 in the southern part of the site to more than 200 feet in the northern part (beneath Alamo Mesa). Fruitland overburden and rock separating coal beds and some Kirtland overburden are excessively high in sodium and salts.

COAL RESOURCES

The estimated identified original coal resources with 200 feet or less of overburden total 81,197,000 short tons in the 4-square-mile area that encompasses the EMRIA study site. The area around and including the study site, about 6 square miles, contains estimated identified original coal resources of 174,443,000 short tons, of which about 62 percent is overlain by 200 feet or less of overburden.

The coal has an apparent rank of subbituminous A. The average Btu value of 16 core samples from the study area on the as-received basis is 8,078. The average ash content of the samples on the as-received basis is 22.2 percent, and the average sulfur content is 0.5 percent. Analyses of 79 samples of coal from the San Juan River region indicate that the concentrations of trace elements are generally below the average for these elements in the continental crust. Only the concentrations of selenium and boron are higher by more than an order of magnitude.

SOIL AND BEDROCK MATERIALS

Study site soil and bedrock materials were observed, sampled for laboratory analysis, and evaluated to determine their suitability as planting media.

Land Suitability

Study site lands were surveyed in order to classify them for their suitability as a source of material for resurfacing and revegetating the area following surface mining. The survey provided data on the quantity, quality, and ease of stripping and stockpiling such material. Assignment of classes was based on field observations, laboratory analyses, and greenhouse studies. Four land classes were mapped at the study site--class 1 (good, 2 percent of study site); class 2 (fair, 8 percent); class 3 (poor, 19 percent); and class 6 (presently unsuitable, 71 percent). Land classes 1, 2, and 3 have material usable as planting media; class 6 has material presently unusable because of severe limitations. Figure 2 shows the extent and location of the four land classes. Classification evaluated about the top 36 inches of surface materials for use as planting media.

Bedrock Suitability

Bedrock overburden at the study site is in two geologic formations--the Fruitland and the Kirtland. Field investigations, greenhouse studies, laboratory analysis, and weathering tests indicate that most bedrock materials are presently unsuitable for use as planting media. Although bedrock materials should not be used in their present state, their use for reclamation purposes may be possible in conjunction with better materials, or after additives (such as gypsum or cinders) are applied, or with good postreclamation management. The usability of bedrock overburden for reclamation purposes needs researching.

Major Land Categories

Four major land categories encompass the landforms and soil bodies of the study site:

Mesas

About 16 percent of the study site consists of mesas, elevated benches, and sandy ridges. These areas generally have some vegetation. Soil depth is usually 60 inches or more, soil textures range from fine sand to clay loam, and soil-moisture relationships (permeability and water-holding capacity) are generally good. Usually no harmful accumulations of chemicals were detected in the surface soils; saline and sodic conditions exist in some of the subsoils in certain locations, however. Most of this land is suitable for use as planting media.

Valleys

About 44 percent of the study site consists of valley lands. Because these valley lands have a wide range of characteristics, they were divided into two groups--sandy and saline-sodic. Depth to bedrock varies from 0 to 15 feet.

Sandy. Many small scattered areas of sandy topsoil (10 percent of study site), varying in size and supporting vegetation, exist at elevations slightly higher than most valley areas. Textures usually range from sand to sandy loam, although some loam and clay loam soils are present. Generally, available water-holding capacity is adequate, especially in surface soils; some subsoils have very low or no permeability. Most surface soils have no harmful accumulations of chemicals, but most subsoils have excessive salinity or sodium or both. Most sandy lands are suitable for use as planting media but are subject to severe wind erosion.

Saline-sodic. These lands (34 percent of study site) are nearly level or very gently sloping. They are usually barren or have scattered sparse vegetation. Scattered throughout are areas of desert pavement, slick spots, surface crusting, and coppice mounds. Except for very shallow sandy eolian material on scattered areas, soils have developed from alluvial material. Textures usually range from loamy sand to clay. Permeability varies; but where a high amount of sodic material occurs, moisture penetration is very restricted or eliminated. Most of these lands, except the shallow eolian deposits, are presently unsuitable as a source of planting media.

Badlands

About 30 percent of the study site consists of badlands. Generally these lands have rough topography consisting of deep drainage channels entrenched in soft shales and sandstone. Almost all these lands are barren. Where soils are present, they are thin and poorly developed; textures range from sandy loam to clay. Because of restricted permeability and high salinity, these soils are considered unsuitable for use as planting media.

Miscellaneous

About 10 percent of the study site, categorized as miscellaneous lands, consists of active dunes, hummocky areas, and stream channels.

Active dunes. Most of the active dunes consist of undulating ridges and small hills and are barren and subject to severe wind erosion. Textures are usually fine sand and sand. Because of their excessive permeability, low water-holding capacity, and erosion hazard, these soils are considered unsuitable for planting media.

Hummocky areas. These lands usually occur in association with inactive dunes and are usually rough and undulating. Vegetation consisting mostly of shrubs nearly covers these areas. Some spots have scattered bedrock, weathered shales, and sandstones at various depths. Textures range from fine sand to sandy clay, and available water-holding capacity is generally poor. The condition of surrounding lands indicates that some saline-sodic conditions interspersed with coarse textured soils can be expected in hummocky lands. Because of the shortage of planting media at the study site, some of these lands must be considered as a source of planting media; however, special care must be taken to prevent severe wind erosion when the vegetative cover is removed.

Stream channels. These lands are composed of deposits associated with major drainage systems. They are usually barren. Soils are subject to severe wind erosion. Textures are usually sandy with deposits of gravel and cobble, and available water-holding capacity is very poor. Stream channel soils are unsuitable for planting media.

VEGETATION AND ASSOCIATED SOIL-MOISTURE RELATIONSHIPS

In general, the vegetation is classified as the southern phase of the northern desert shrub type. The most abundant species are alkali sacaton, four-wing saltbush, saltbush, Indian ricegrass, and sand sagebrush. The abundance of several other species--such as Russian thistle, snakeweed, and annual mustard--indicate range deterioration caused by past heavy use by livestock. An estimated 51 sections of the present vegetation would be required to support a 300 animal-unit ranch (hence the study site would support roughly 24 animals). If the sandy habitat that now supports alkali sacaton could be increased following mining, forage production would be considerably increased.

Use of precipitation for producing vegetative cover could be made more efficient than at present if during mining and rehabilitation the soil materials are removed, stockpiled, and repositioned properly. Optimum soil-moisture conditions and highest efficiency would require that a foot or more of fine-textured alluvium or residuum be placed first. Next, 12 to 16 inches of sandy alluvium, composed of particles of various sizes, should be placed over the fine-textured material. Such layering will cause water to be temporarily stored at low soil-moisture stresses and thus be readily available to vegetation. Observations indicate that tall grasses such as alkali sacaton and sand dropseed dominate areas where these conditions of layering and optimum depths of sandy material occur naturally.

The minimum depth of sandy material over fine-textured material should be about 8 inches. A sparse cover of saltbush, alkali sacaton and forbs

occur naturally on areas with this minimum depth of sand. In areas where the sandy material is thicker than optimum, water is held in thinner films and is less readily available. In such areas, mid and short grasses such as Indian ricegrass, ring muhly, galleta, and blue grama occur, along with deep-rooted shrubs such as sand sagebrush, torrey ephedra, and snakeweed. Greasewood occurs on deep sandy areas where ground water is relatively deep.

Fine-textured soil materials are a poor medium for vegetative growth because they are poorly permeable, and water is held in thin films by them because of their large amounts of particle-surface area. Also, evaporation is relatively large from fine-textured materials because much of the water is retained near the ground surface. Coal and its weathering products have even greater particle-surface areas and thus make water less available to vegetation. Soil materials contaminated with coal, therefore, should not be used for rehabilitation. The permeability of fine-textured materials can be improved by ponding water on the surface or by repeated irrigations at controlled rates. Ponding can be accomplished by furrowing or pitting the soil surface or by facilitating the formation of snowdrifts, from which the release of meltwater is slow.

INFILTRATION AND SOIL DETACHABILITY

Erosion occurs when infiltration rates are exceeded and runoff waters flow across soil materials that are highly susceptible to detachment. Infiltration rates are low in the actively eroding badlands and in areas where clayey alluvium is exposed. Infiltration rates are high in sandy areas. Detachability is low for the clayey materials and is high for the sandy materials. To minimize erosion following mining and rehabilitation, runoff should be prevented or minimized by: (1) placing sufficient sandy material on the surface or (2) contour furrowing or pitting areas with clayey materials on the surface to enable absorption of the water from the most severe storm expected during the revegetation period.

SEDIMENT YIELDS

Sediment yields are low (.05 to .4 acre-ft/mi²/yr) from Alamo Mesa and from much of the valley area consisting of alluvial plains mantled with scattered sandy deposits. Sediment yields are moderate (.4 to 1.2 acre-ft/mi²/yr) from some gullied parts of the alluvial plains where sheet erosion is severe and from low badlands within the alluvial plains. High sediment yields (1.2 to 3.2 acre-ft/mi²/yr) occur from the steep badland areas. Estimated sediment discharges of the streams that pass through the study area are moderate to high (.5 to 1.2 acre-ft/mi²/yr) owing to the sediment yields of the steep badlands and to the flushing of windblown sand that accumulates in the channels.

Diversion of the main channels of De-Na-Zin Wash and Coal Creek around the prospective mining area is not recommended since it would result in considerable erosion of the diversion channel and significantly increase the sediment discharge of De-Na-Zin Wash until the channel stabilizes.

Required diversion of southward-flowing tributaries of De-Na-Zin Wash around the north end of the prospective mining area would cause some erosion of the diversion channels and thus slightly increase the sediment discharge of the wash until the channels stabilize. However, these diversion channels will drain a much smaller area and the increase in sediment discharge will not be as great as from diversion of De-Na-Zin Wash and Coal Creek.

After vegetation is established, and reconstructed drainageways have stabilized, sediment yields may not exceed the present rates.

HYDROLOGY AND WATER SUPPLY

Local surface water supplies are scarce. Arroyos in the area flow sporadically as a result of localized, short-duration, high intensity storms, usually during summer and early autumn. Runoff is estimated at 4 acre-feet/mi²/yr for sandy soil and at 40 acre-feet/mi²/yr for badland areas. The 50-year peak flow at De-Na-Zin Wash outflowing from the coal area is estimated to be 37,900 cubic feet per second.

Chemical quality of surface waters generally appears suitable for revegetation, but this preliminary appraisal should be confirmed if use of these waters becomes a reality. To make use of surface waters, impoundment would be necessary.

All surface flows are accompanied by high suspended sediment concentrations. Total dissolved solids concentration of surface waters range from 300 to 2,000 milligrams per liter (mg/l), most of which is sodium (Na), sulfate (SO₄), and bicarbonate (HCO₃). Suspended sediment concentrations range from 3,000 to 250,000 mg/l, most of which is clay or silt. Impounded surface water tends to concentrate Na, SO₄, HCO₃, and boron to levels which may cause salinity hazards to soils and plants if used for irrigation. Other constituents do not appear to be present at harmful levels for irrigation use.

Shallow alluvial deposits, including those in arroyo channels, contain small, localized supplies of ground water with quality better than that in deeper ground water bearing formations. The latter yield highly saline waters with total dissolved solids concentrations usually exceeding 3,000 mg/l; an exception may be the Morrison Formation, potentially the best formation for developing a ground water supply. The alluvial deposits and the Morrison Formation are possible alternative sources of irrigation water.

The Kirtland, Fruitland, and Pictured Cliffs Formations would be the ground water-bearing formations to experience the greatest hydrological impact from coal mining, but it is anticipated that this impact will not seriously affect the natural low yield and inferior water quality of those formations.

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